

Application S/N 10/034,221
Reply to Office Action of June 6, 2003

Patent
Attorney Docket No. CU-2755

REMARKS/ARGUMENTS

Reconsideration is respectfully requested.

The replacement sheets of FIGS. 1-6 attached hereto include bigger size reference numerals and/or characters that are considered to have met the requirement under 37 CFR 1.84(p)(1). No new matter has been added. Withdrawal of the objections to the drawings is respectfully requested.

Claims 1-13 are pending in the present application before this amendment. By the present amendment, Claims 1 and 7 have been amended. No new matter has been added.

Claims 1 and 4-6 stand rejected under 35 U.S.C. § 102(b) as being unpatentable over Wolf et al., Silicon Presprocessing for the VLSI Era Volume 1: Process Technology, Lattice Press, Sunset Beach, CA, USA, pp. 1-35, 124-159, 1986 (Wolf). The "et al." suffix appearing after the author's name is omitted.

Claims 2-3 and 7-13 stand rejected under 35 U.S.C. § 103(a) as being obvious over Wolf.

As to the independent Claims 1 and 7, it is respectfully noted that Applicant is not just claiming the Czochralski (CZ) crystal growth technique, which is well known by those skilled in the pertinent art. The cited Wolf discloses this well-known, conventional CZ technique in a manner a typical college textbook material would. Nevertheless, Wolf fails to teach or disclose the presently claimed invention.

The presently claimed invention is directed to, inter alia, growing an epitaxial layer on a

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carbon doped silicon wafer. An ingot of carbon-doped silicon can be grown using the CZ technique or any other techniques according to the presently claimed invention. The CZ technique is merely a tool utilized in the presently claimed invention and is not at all that is directed wholly by the presently claimed invention.

As a first point of distinction, Wolf does not teach or suggest, inter alia, the claimed step of heating a quantity of carbon and another quantity of silicon (i.e., not quartzite) to obtain a molten silicon and carbon. In Wolf, carbon is added to the raw material quartzite (SiO_2) to refine the quartzite to polycrystalline silicon. The addition of carbon in Wolf is a pre-refining step to produce polycrystalline silicon from which to grow single crystal silicon utilizing the CZ method. That is, Wolf does not teach mixing and heating of carbon and silicon to produce a carbon doped silicon wafer.

Wolf at page 6 teaches the method of growing a "single crystal silicon" from "raw material (quartzite)." In the distillation and reduction process of Wolf, carbon is added to the raw material (quartzite) to obtain polycrystalline silicon (see Wolf pages 6-8). Then, CZ method is applied to the polycrystalline silicon to grow single crystal silicon (see Wolf pages 8-21). This is quite different from the presently claimed invention that teaches adding carbon to silicon to grow carbon-doped silicon crystals.

Wolf does not teach or encourage adding any impurity to the molten polycrystalline silicon by utilizing the CZ technique. Wolf is directed to growing single crystal silicon in its purest form as possible utilizing the CZ technique. Wolf teaches against adding carbon or any impurity to grow, for example, the claimed carbon-doped silicon ingot. As described in Wolf,

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pages 18 and 27, carbon is an undesirable impurity that ends up in the silicon crystals grown from the molten polycrystalline silicon. Wolf at page 27, for example, describes that 1-5 ppma of carbon is inevitably present in a silicon crystal grown by the CZ technique.

Nevertheless, Claims 1 and 7 have been amended to include the limitation —wherein the density of carbon in the ingot is greater than 5 parts per million atoms (ppma)—, and this limitation clearly distinguishes the presently claimed invention from Wolf.

The Office Action states regarding Claim 7 that:

“... it would have been obvious to one of ordinary skill in the art at the time of the present invention to mix carbon with Si and then melting together the Si and C to form a melt because Wolf et al. suggest just such Si with C impurity as being common in the art.”

Applicant respectfully disagrees. As discussed above, there is no teaching or suggestion in Wolf about intentionally mixing and heating carbon and silicon (not quartzite as in the case of Wolf) to produce carbon doped silicon. Wolf describes merely that carbon may be present in the single crystal silicon ingot as an undesired byproduct of the process (in the amount of 1-5 ppma when the CZ technique is utilized). The presence carbon in Wolf is unintentional and unwanted byproduct of the process.

As understood by Applicant, carbon is not generally understood by those of ordinary skill in the pertinent art to be a most common type or preferred impurity to be used as a dopant material to silicon. In general, as understood, the common dopant atoms are boron (B), phosphorus (P), antimony (Sb), gallium (Ga), aluminum (Al), arsenic (As), etc. belonging to Groups 13 and 15 of the Periodic Table.

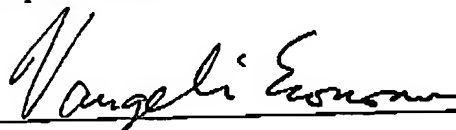
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Therefore, it is respectfully asserted that the conclusive statement of obviousness (i.e., "it would have been obvious to one of ordinary skill in the art at the time of the present invention to mix carbon with Si and then melting together the Si and C to form a melt") is based on an impermissible presumption. Applicant's response to such a conclusive statement of obviousness is that the basis for improperly finding the presently claimed invention obvious appears to be the teaching found in this application, and not in the prior art. Thus, the obviousness rejection in the Office Action improperly relies on the impermissible hindsight reasoning, because the rejection would not be obvious absent Applicant's disclosure in this application. (See 37 C.F.R. § 1.104(c)(2).)

For the reasons set forth above, Applicants respectfully submit that Claims 1-13, pending in this application, are in condition for allowance over the cited references. This amendment is considered to be responsive to all points raised in the Office Action. Accordingly, Applicant respectfully requests reconsideration and withdrawal of the outstanding rejections and earnestly solicits an indication of allowable subject matter. Should the Examiner have any remaining questions or concerns, the Examiner is encouraged to contact the undersigned attorney by telephone to expeditiously resolve such concerns.

Respectfully submitted,



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Vangelis Economou, Reg. No. 32,341
c/o Ladas & Parry
224 South Michigan Avenue
Chicago, Illinois 60604
(312) 427-1300

Attachments